

THERMOFORMABLE ACOUSTIC MATERIAL

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority under 35 U.S.C. § 119(e) on U.S. Provisional Application No. 60/454,148 entitled THERMOFORMABLE ACOUSTIC SHEET MATERIAL, filed March 12, 2003, by Kyle A. Ray, the entire disclosure of which is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] This invention relates to a thermoformable acoustic sheet material, and in particular to thermoformable multiple layer sheet materials that are lightweight and exhibit an outstanding combination of acoustic absorption, acoustic barrier, and/or vibration damping characteristics.

BACKGROUND OF THE INVENTION

[0003] Thermoformable acoustic insulating and/or sound absorbing sheet materials are employed in substantially all mass produced motorized vehicles having a weather-tight passenger compartment. Thermoformability refers to the ability of the sheet material to be shaped in a molding tool under application of heat and, optionally, pressure, and subsequently retain the molded shape. It is highly desirable that the thermoformable acoustic sheet material used for molding sound insulating and/or sound absorbing panels for motorized vehicle applications has properties that impart resilience and flexibility to the finished panels. This combination of thermoformability, flexibility and resilience or shape-retention facilitates economical installation of the acoustic panel into the vehicle by allowing the panel to be bent during installation, such as to fit the panel into an obstructed space, without damaging or permanently deforming the shape of the panel, and by ensuring that the panel will conform as precisely as needed to the contours of a vehicle component without extensive laborious manipulation of the panel.

[0004] In addition to thermoformability, flexibility and resilience, all of which are important for achieving economical manufacturing and/or installation of the acoustic panel, there is a need for progressively thinner acoustic panels in order to maximize space availability for other

vehicle components, passengers and cargo. Further, there is also a progressive need for lighter weight acoustic panels in order to minimize fuel consumption.

[0005] Accordingly, it is an object of this invention to provide a thermoformable acoustic sheet material that is flexible and resilient, thin, light in weight, low in cost, and exhibits outstanding acoustic absorption, acoustic barrier, and/or vibration damping properties.

SUMMARY OF THE INVENTION

[0006] A multiple layer, thermoformable acoustic sheet material in accordance with this invention includes a barrier layer of fibers having an area weight of from about 40 grams per square foot to about 100 grams per square foot, and an absorber layer of vertically-lapped fibers. The multiple layer, thermoformable acoustic sheet materials of this invention are useful for manufacturing acoustic absorption, acoustic barrier, and/or vibration damping components for various applications, especially in motorized vehicles such as automobiles and trucks.

[0007] These and other features, advantages and objects of the present invention will be further understood and appreciated by those skilled in the art by reference to the following specification, claims and appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Fig. 1 is cross-sectional, diagrammatic view of a thermoformable acoustic sheet material including a barrier layer and an absorber layer.

[0009] Fig. 2. is a cross-sectional, diagrammatic view of a thermoformable acoustic sheet material including a barrier layer, an absorber layer, and a polymer film layer disposed between the barrier layer and the absorber layer.

[0010] Fig. 3 is a cross-sectional diagrammatic view of a thermoformable acoustic sheet material including a barrier layer, an absorber layer, and a scrim layer disposed between the barrier layer and the absorber layer.

[0011] Fig. 4 is a cross-sectional diagrammatic view of a vertically-lapped nonwoven fibrous mat that may be utilized in the thermoformable acoustic sheet materials of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] Shown in Fig. 1 is a thermoformable acoustic sheet material 10, which in accordance with the invention includes a barrier layer 12 of fiber having an area weight of from about 40 grams per square foot (about 430 grams per square meter) to about 100 grams per square foot

(about 1076 grams per square meter) and a typical thickness of from about 1 millimeter to about 5 millimeters, and an absorber layer 14 of vertically-lapped fiber, wherein the absorber layer has an area weight of from about 25 grams per square foot (about 270 grams per square meter) to about 100 grams per square foot (about 1076 grams per square meter) and a typical thickness of at least about 15 millimeters. The indicated thicknesses refer to the thicknesses of the layers of the thermoformable acoustic sheet material before it has been shaped or molded in a tool under application of heat and, optionally, pressure. After shaping or molding of the thermoformable acoustic sheet material, the layers 12, 14 will typically have variable thicknesses ranging up to the original thicknesses of the layers prior to thermoforming.

[0013] The thermoformable acoustic sheet materials of this invention include two or more layers, each layer having a length and width that is typically at least an order of magnitude greater than the thickness of the layer, which are attached to one another in overlapping relationships so that the total thickness is approximately the sum of the thicknesses of the individual layers. The thermoformable acoustic sheet materials of this invention are thermoformable sheet materials that exhibit sound insulative, sound absorptive, sound barrier, and/or other sound attenuative properties. In particular, the thermoformable acoustic sheet materials of this invention may be appropriately shaped or molded and installed between the engine compartment and the passenger compartment of a motor vehicle, and/or on the roof, floor, and/or doors of a vehicle to reduce the amount of engine and/or road noise in the passenger compartment of the motor vehicle.

[0014] The barrier layer is a relatively high density layer of nonwoven fiber that has been compressed to form a sheet or layer having an area weight of from about 40 grams per square foot to about 100 grams per square foot and a thickness of from about 1 millimeter to about 5 millimeters. The barrier layer typically exhibits excellent sound transmission barrier properties superior to that of the absorber layer. The barrier layer 12 may be vertically-lapped, air-laid, cross-lapped, needle-punched or the like.

[0015] The absorber layer is a relatively low density material that is typically lofted to achieve an area weight of from about 25 grams per square foot to about 100 grams per square foot for a thickness that is at least about 15 millimeters, more typically from about 20 to about 40 millimeters (prior to thermoforming of the acoustic sheet material), although greater thickness

may be used for certain applications. The absorber layer exhibits superior sound absorptive properties as compared with the barrier layer.

[0016] The barrier layer and the absorber layer may be attached to one another either directly, such as by needle-punching through the layers so that fibers in at least one of the layers penetrate into and become intertwined with fibers in the other layer, or indirectly, such as with a polymer film layer disposed between, and bonded to each of, the barrier layer and the absorber layer.

[0017] It has been discovered that a highly efficient absorber layer that is lightweight and relatively thin can be achieved by utilizing vertically-lapped synthetic fiber, natural fiber, mineral fiber or any combination of synthetic, natural, and mineral fiber. The vertically-lapped fibrous layer has been shown to provide improved sound absorption as compared with a conventional high loft material using the same fibers and same weight and/or density. A vertically-lapped fibrous layer or batt is a nonwoven fibrous layer or batt that has been repeatedly folded back and forth onto itself (i.e., pleated) to produce a vertically folded sheet material in which the fibers are predominantly or at least preferentially oriented with the length direction of the fibers being parallel with the thickness direction of the layer or batt. Vertically-lapped nonwoven materials are also referred to as variable compression fabric. Vertically-lapped materials may be produced by utilizing standard textile fiber blending equipment (if a mixture of fibers is used) and standard textile carding equipment to form a nonwoven web. The carded nonwoven web is then fed into a vertical lap machine which folds the web back onto itself to form a vertically-lapped or pleated structure. The vertical laps are preferably thermally bonded together, such as by using a flatbed conveyor convection oven. A vertically-lapped nonwoven fibrous mat that may be employed in the thermoformable sheet materials of this invention is shown in Fig. 4. The illustrated vertically-lapped nonwoven fibrous mat 40 comprising a carded fiber web 41 that is repeatedly folded upon itself to form a multiplicity of adjacent vertical laps or pleats 42. This vertically-lapped structure is utilized in the absorber layer 14 of each of the embodiments illustrated in Figs. 1, 2 and 3, and may be employed in the barrier layer 12.

[0018] It has also been discovered that vertically-lapped fiber may be advantageously, but not necessarily, employed in the barrier layer 12.

[0019] The fibrous layers used in the thermoformable acoustic sheet materials of this invention may be prepared using any suitable technique, such as conventional dry-laid web formation processes, including carding, air-laying, etc. The resulting webs may be further processed, i.e., vertically-lapped, cross-lapped, needle-punched, thermal bonded, hydroentangled, chemically bonded, etc.

[0020] Fig. 2 shows another embodiment of the invention wherein a polymer film layer 16 is disposed between barrier layer 12 and absorber layer 14. Polymer film 16 is a relatively thin, substantially continuous sheet of material comprising a polymer. The polymer film may be conveniently used for adhesively attaching barrier layer 12 and absorber layer 14 together. This may be achieved by utilizing a polymer film 16 having a pressure sensitive adhesive disposed on the opposite sides of the film. Alternatively, polymer film 16 may be used as a hot melt adhesive for bonding layers 12 and 14 together. Alternatively, or in addition, polymer film 16 may be used for enhancing the acoustic barrier properties of thermoformable acoustic sheet material 20. While there is not a precise upper or lower limit for the thickness of polymer film 16, polymer film 16 may typically have a thickness of from about 1 to 20 mils. However, it is possible to use thinner and/or thicker films if desired. Suitable polymer films include polyolefin films (e.g. polyethylene), polyethylene terephthalate films, etc. An example of a commercially available polymer film that may be used is INTEGRAL™ 906 polyolefin multilayer adhesive film, which is an impermeable film available from the Dow Chemical Company. In this embodiment, the layers 12 and 14 may each, independently comprise vertically-lapped, air-laid, cross-lapped, needle-punched or other nonwoven fibrous arrangements.

[0021] Contrary to common belief and practice, it has been discovered that thermoformable sheet materials having excellent acoustic barrier/absorption properties can be prepared by combining fibrous layers with an impermeable polymer film. Permeable polymer films and scrims have been used in the manufacture of thermoformable acoustic sheet materials to impart improved sound absorption properties and to shift the frequency at which peak absorption occurs, i.e., tune the barrier for a particular application. It was previously believed that the polymer film or scrim must be permeable or be made permeable in order to achieve the desired sound barrier/absorption properties. The use of an impermeable film between fibrous layers

has the advantage of providing a lower cost thermoformable sheet material having excellent acoustic barrier/absorption properties as compared with known thermoformable acoustic sheet materials having a permeable scrim or perforated polymer film layer. This is due to the fact that spun-bonded filament and other scrims, as well as perforated films, require more complicated and expensive manufacturing processes. The term "impermeable film" as used herein means a film that has an airflow resistance not less than about 5000 Rayls.

[0022] In accordance with another embodiment of the invention, a thermoformable acoustic sheet material 30 comprising a barrier layer of fiber 12, an absorber layer of vertically-lapped fiber, and a scrim 18 between the barrier layer and the absorber layer is shown in Fig. 3. A scrim is a relatively thin and durable woven fabric which may be comprised of synthetic or natural fibers. Scrim layer 18 may be used for attaching layers 12 and 14 together, such as by applying an adhesive to opposite sides of scrim 18 before disposing scrim 18 between layers 12 and 14. The use of scrim layer 18 in thermoformable acoustic sheet material 30 has been found to enhance acoustic absorption properties.

[0023] The thermoformable acoustic sheet materials of this invention may be utilized in the manufacture of acoustic insulative carpet systems. In this case, barrier layer 12 comprises a carpet. For example, a latex backed carpet (e.g., 12 ounce of latex per square yard of carpet) was attached to a lofted, vertically-lapped polyester (polyethylene terephthalate) layer having a area weight of from about 60 grams per square foot to about 100 grams per square foot, a thickness of about 35 millimeters, and an airflow resistance of less than 100 Rayls, to provide a lightweight, relatively thin, economical carpet system exhibiting outstanding sound insulative properties. Airflow resistance may be determined in accordance with ASTM C522-87, "Standard Test Method for Airflow Resistance of Acoustic Materials."

[0024] In order to provide a thermoformable acoustic sheet material, the barrier layer may include synthetic fibers that can be thermally fused together during a thermoforming operation to provide a flexible, resilient finished product conforming to the contours of a vehicle component to which the shaped product is to be mounted. Suitable synthetic fibers for imparting thermoformability include various thermoplastic fibers that can be softened and/or partially melted upon application of heat during a thermoforming process to form a multiplicity of bonds at fiber-fiber intersections to impart flexible and resilient shape retention properties.

Examples of suitable thermoplastic fibers include fibers comprised of homopolymers and copolymers of polyester, nylon, polyethylene, polypropylene and blends of fibers formed from these polymers and copolymers. Particularly suitable are composite or bicomponent fibers having a relatively low melting binder component and a higher melting strength component. Bicomponent fibers of this type are advantageous since the strength component imparts and maintains adequate strength to the fiber while the bonding characteristics are imparted by the low temperature component. A variety of bicomponent fibers of this type are commercially available from various sources. One suitable fiber for use in the present invention is a sheath-core bicomponent construction wherein the core is formed of a relatively high melting polyethylene terephthalate (PET) polymer and the sheath comprises a PET copolymer having a lower melting temperature which exhibits thermoplastic adhesive and thermoformability properties when heated to a temperature of about 110 to 185°C.

[0025] In addition to, or in place of, the synthetic fibers, the thermoformable acoustic sheet material may comprise various natural fibers of plant or animal origin and/or mineral fibers. Examples of natural fibers include kenaf, grasses, rice hulls, bagasse, cotton, jute, hemp, flax, bamboo, sisal, abaca and wood fibers. Examples of mineral fibers include glass, ceramic and metal fibers.

[0026] Although the thermoformable acoustic sheet material preferably includes sufficient melt-fusible or adhesive synthetic fibers to impart suitable thermoformability and shape retention properties, it is possible to achieve satisfactory thermoformability and shape retention properties for certain applications by incorporating only a very small percentage of adhesive synthetic fibers, or possibly none at all, by partially impregnating or coating the fibers with either a heat-fusible thermoplastic resin or a thermosettable resin (such as a thermosettable resin in which curing is initiated by application of heat).

[0027] The barrier layer may be comprised of generally any combination of natural, synthetic and/or mineral fibers (such as the natural, synthetic and mineral fibers mentioned above). However, in order to economically achieve the desired properties, natural fibers and/or combinations of natural and synthetic fibers may be preferred for certain applications.

[0028] The above description is considered that of the preferred embodiments only.

Modifications of the invention will occur to those skilled in the art and to those who make or use the invention. Therefore, it is understood that the embodiments shown in the drawings and described above are merely for illustrative purposes and not intended to limit the scope of the invention, which is defined by the following claims as interpreted according to the principles of patent law, including the doctrine of equivalents.